Contributions of Workflow to quality requirements

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ABSTRACT. A process is a set of activities which produces an output -product or service- valuable for the customer. Ensuring quality of products and services requires high amounts of cooperation between the different actors in an organization. This suggests the use of workflow techniques in order to implement quality. Workflow management systems allow the control of flow of work and guarantee that a job shall execute in accordance with a predefined structure. We show how workflow management systems can be instrumental in satisfying quality requirements which are defined in the ISO 9000 standard. Also, the manner in which workflow facilitates the satisfaction of the five essential principles of TQM is shown.

KEY WORDS. Cooperative work process, Workflow, Quality, Organization, Reengineering.

INTRODUCTION

Individual activities become integrated into group work, involving collaboration, cooperation, coordination and communication. An organization is a set of work processes and work groups which coordinate their activities, cooperate and negotiate with other people.

Organizations are built on the principle that groups can carry out tasks which are not feasible individually. The effectiveness of the organization depends on the efficiency of groups which constitute it. The efficiency of the group, in turn, depends on the cooperation between its members and the decisions produced by them. In a company, various functions are shared out among different actors. Then, even if competencies of each actor are proved, the convergence of everybody's effort requires coordination among the activities of the actors and use of a method to reach the expected quality [NUR 96a, ROL 97a]. Economical and commercial stakes related to quality are very important and there is a strong correlation between outcomes of quality management and financial results of a company .

It is necessary to emphasize the specifics of cooperative processes in order to take them into account as soon as possible during the design [NUR 96b, NUR 96c, NUR 97, ROL 97b]. In [MED 92], three kind of processes are distinguished depending on the resources that are being studied: material processes, information processes and business processes. Industrial engineering is concerned with improving the manufacturing processes. Information systems analysis improves the availability and accuracy of information that is vital to a business. As the materials and information processes become more efficient, costs become concentrated in the business processes -the way people work together to achieve the goal of the organization. Assuming that the basic units of any organization are the work processes performed within it constitutes a radical shift in organizational analysis. This point of view offers a useful insight into work practices to designers of computer supports [AGO 93].

Workflow management systems are computer-based tools devoted to support work processes. They support multi-user applications managing the routing of individual activities, integrating them, eliminating all the interactions due to the lack of that integration and giving their users a global view in the procedure they are involved in. In this paper, we present how workflow management systems can be instrumental in satisfying quality requirements of business processes. The paper is organized as follows:

In the second section, we first show the relationship between workflow and Computer Supported Cooperative Work (CSCW). Then we consider the features of workflow and we present a typology of CSCW applications with regards to the nature of business processes they support. Finally, we conclude that project oriented structures, thanks to the new information and communication technologies, lead to horizontal organizations.

In the third section, we introduce the quality approach. We show the quality movement and introduce ISO 9000. To conform to this standard it is necessary "to write what is done, to do what was written and to prove what was done". This requires a strict management of documents which constitute the quality manual and a tight monitoring system to ensure that procedures are indeed respected.

In the fourth section, we deal with the manner in which workflow helps in satisfying quality requirements. The use of a workflow management system may be crucial in the documentation and improvement phases. Automation due to use of workflow techniques makes it impossible to violate established procedures. This has obvious implications on quality. Since information like duration, frequency etc. concerning procedures can be kept in the workflow application, it is possible to determine the effectiveness of the corresponding business processes.

COMPUTER SUPPORTED COOPERATIVE WORK

Cooperative work or group work is the object of a multidisciplinary research field called Computer Supported Cooperative Work [BOW 91, GRE 90]. CSCW looks at how groups work and seeks to define how technology can help them work. In the cooperative work area, the past decade witnessed the emergence of many technologies. The growth of information technology (for example, server technology) and communication technology (such as email) greatly expanded opportunities for office workers to cooperate and work together.

Peter and Trudy Johnson-Lentz in 1978 defined groupware as a system which facilitates group work. Thirteen years after, groupware is defined in [ELL 91] as follows: "*Computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment*". This definition clarifies that group work involves a common task (or goal) and a shared environment. A well-known categorization is the division into synchronous or asynchronous activity and co-located or distributed activity represented in the Johansen's space/time matrix [JOH 91].

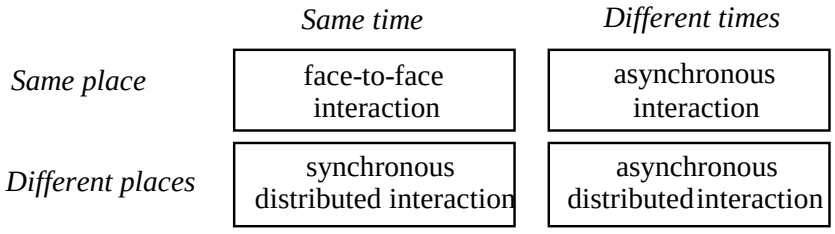

Figure 1 - *Johansen's Space/Time matrix*

This can be useful in quickly categorizing, but it has limitations. According to Jonathan Grudin, "*An e-mail system supporting discrete point-to-point communication is very different in nature from a work management system designed to support a large project over a period of years*". In his 3x3 matrix [GRU 94a], Grudin differentiates between activity that occurs at different and predictable times and places, and at different and unpredictable times and places.

Workflow

There are many definitions of what a workflow management system does. According to us, the one of Ovum is the most complete: *« Workflow management software is a proactive computer system which manages the flow of work among participants, according to a defined procedure consisting a number of tasks. It coordinates user and system participants, together with the appropriate data resources, which may be accessible directly by the system or off-line, to achieve defined objectives by set deadlines. The coordination involves passing tasks from participant to participant in correct sequence, ensuring that all fulfill their required contributions, taking default actions when necessary »* [OVU 91].

Workflow applications focus on the control of the information flow between various objects in the office with respect to a predefined procedure. The objects could be office workers, database servers, application files, etc. [KHO 92]. Workflow management systems allow the office workers to construct a diagram by linking nodes representing the office objects involved in the workflow. The links, between nodes of a workflow, control the flow of the information. In other words, workflow concerns, at first, an activity of scheduling and coordination of work between actors implicated in business processes.

For many people, groupware deals with the problem of making easier those group interactions which are unpredictable and dynamic whereas workflow tries to automate strategies and predefined procedures. However, their global aims are the same: to increase the collective efficiency of groups of people engaged in a common goal. In workflow applications, cooperative work means that several persons are involved in reaching a common goal, but each of them acts individually in a different step (task) of the work. Ellis definition specifies that the group work involves a common goal and a shared environment. In fact, if we take a general view of the procedure, there is a common goal to reach by a group of people which share information.

Workflow is classified in the distributed asynchronous area of the Johansen's time/space matrix as electronic mail systems.

- *"..., workflow systems , and group calendars are key examples of groupware"* [GRU 94b].
- *"... workflow is a subset of groupware"* [REI 93].

Principal features of workflow

Workflow should be regarded as a means for allowing decentralization of organizational structures. The aim of workflow analysis is to find the right division of a given work process into tasks and an ordering among these tasks leading thus to the representation of a ″procedure″. Thereafter, workflow management systems provide mechanisms to execute the defined flow of tasks [ELL 79, KUR 87].

A procedure is a predefined set of partially ordered tasks. Thus, loops and parallelism can be handled. To describe task order, disjunctive and conjunctive logical operators are necessary, with the possibility to combine them. A task is composed by actions performed by only one actor having a given role in the work process. Each task is assigned to a role which itself is associated to a group of actors. The actor who will execute the task will be chosen from among this group (see figure 2):

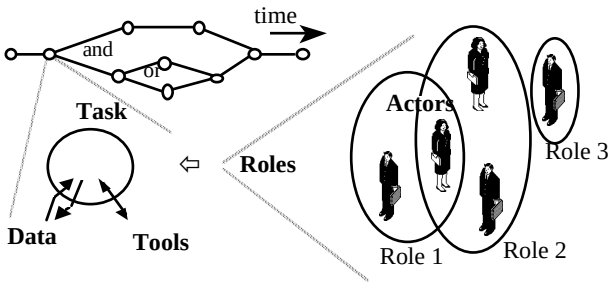

Figure 2 - *Procedure representation*

Workflow application development starts with the modeling of the cooperative process to automate. Each workflow management system proposes its own model to graphically represent procedures. Models are numerous but there are a few theoretical studies on which they are founded. Two types distinguish themselves:

- Petri net based, and
- Speech Act Theory [SEA 69, SEA 75, WIN 88] based.

The two principal models corresponding to these studies are ICN [ELL 79] and Action Workflow [MED 92] respectively. Both use a top-down approach which enables the choice of the abstraction level of the representation and the modeling of a complex process by successive decompositions.

The principal features of workflow management systems are given below:

- *a strict respect of procedures:* workflow management systems impose a rigorous scheduling of facts. This guarantees that work is done in accordance with the predefined structure and makes easier the implementation of business processes according to ISO 9000 standards (see section *Contribution of workflow to implement quality*). Workflow management systems facilitates the management of complex business processes, making it possible :

  . to define different ways of processing according to various situations (switches depending of case variables),

  . to affect tasks to actors according to circumstances (with regards to work loads, absences...),

  . to execute parallel tasks in order to reduce the required time for the work process.

- *the control of the flow of tasks:* workflow management systems allow the tracing of the progress of work step by step. This enables the swift detection of an abnormal accumulation of work for a worker and the removal of such bottlenecks by assigning parts of this work to others. Workflow management systems provide the means to control the efficient carrying out of cooperative work in the required time rather than being tools to supervise individual activities. They give a general view of the situation at a given time in terms of flow of works. If it seems difficult to control file accumulations in offices, it is very easy to count the number of messages in an electronic queue. Thanks to appropriate indicators, other possibilities such as statistics, quantify the company's activity and allow to measure the effectiveness.

- *high automation*: another interesting characteristic of workflow management systems concerns the automatic flow of tasks from one place to another, and also the automated supply of necessary information to the right actors at the right moment. Thus, time spent on searching, copying, distributing and classifying documents is significantly reduced. Workflow management systems also permit the automation of tasks for which human intervention is not really necessary. This can be, for example, data entry that can be avoided because it corresponds to already known information. Indeed, workflow offer the possibility to collect, than to circulate data along the work process.

Important consequences of these new possibilities should be, increased productivity, greater capacity to react to market risks, reduction in production and response delays, and an improvement in the quality of products and services.

Typology of CSCW applications

CSCW applications have been divided into two different categories depending on the nature of the business processes they support [PAL 92]. The first category concerns well-structured and repetitive work having important coordination and automation needs [NUR 95a], [NUR 96c]. This is the case for most of the office procedures. The second category of CSCW applications deals with occasional and ill-structured (ad-hoc) processes in organizations for instance, decision meetings, brainstorming or problem solving activities. The essential preoccupation with this kind of application is the information and knowledge-sharing in the work group more than the coordination of their tasks: products dedicated to communication, conversation and argumentation are needed. Nevertheless, well-structured and ill-structured work processes often coexist in organizations and must be managed in the final solution [NUR 95b], [NUR 96b], [NUR 98]. The integration aims to make transparent the transition between different types of group activities. This requires homogeneity and coherence of handled concepts. Frequently, users ask for adaptive workflow management

systems and models which can provide the robustness and the security of the predefined procedures and the flexibility of ad-hoc applications [NUR 96a].

Group size is an important feature for cooperative work [DEN 91]. We can regard the integration of groupware in a workflow application as an integration of small groups carrying out some tasks in a larger group required by the entire process (figure 3).

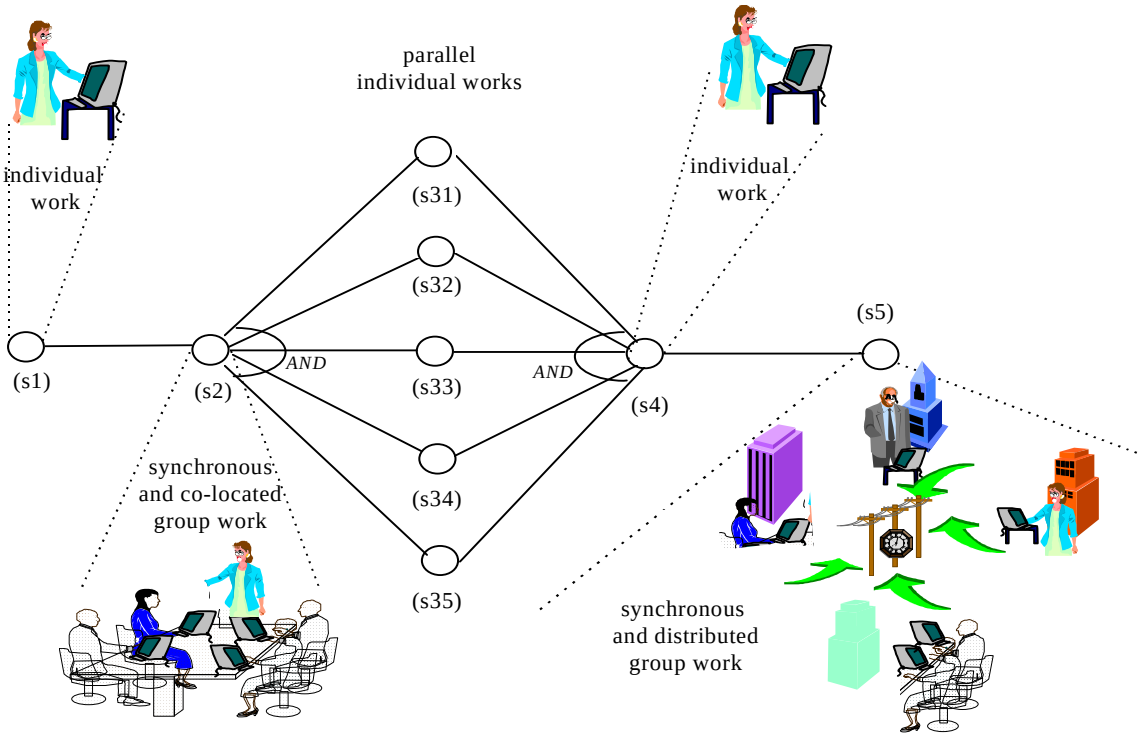

Figure 3 - A well-defined asynchronous cooperative process coordinating individual and cooperative works

For instance, the result of a well-structured process implemented using a workflow management system could be a document collaboratively created in successive steps of (1) subject proposal by any person in the organization to people having some interest in it (2) brainstorming for all participants and task distribution between the authors, (3) individual drafting by each of them, (4) integration and consistency checking and (5) validation. Let us suppose that the second step is a cooperative activity and requires the use of a synchronous groupware tool by the authors concerned with this redaction. In this step, the brainstorming allows to collect the key ideas that shall be put in the document and to prepare its outline; chapters are distributed to the authors; the principal author who has to integrate and to check the consistency and the reviewers who should validate the document are chosen. This step can also lead to the decision that the redaction is not possible. In the case when it leads to a plan of work and a distribution between authors, the drafting is done by each of the concerned authors using an individual word processing tool (step 3). The integration and checking are realized by the principal author using the same word processing tool during step 4. Finally, the

last activity (step 5) requires a synchronous and distributed tool offering vote functions and group oriented editing facilities. The distribution characteristics is required because for some reasons, the reviewers can not meet in the same place. The organization of meetings in the first and last steps concerns people whose decisions will allow the procedure to continue and/or to end. As we illustrated in this example, workflow applications contain predictable activities, but these activities can be individual (using individual software) or collective (using groupware) [NUR 96b], [NUR 96c].

Workflow management systems and other groupware shall give the company the necessary competitive advantages to maintain or to improve its position in the market by responding better and faster to customers [NUR 96d]. The outcome of a new technology is always the opportunity to wonder about the most appropriate organization with respect to the existing activities, the characteristics of the company and the social factors [HAM 90, HAM 93].

Project oriented structures leading to horizontal organizations

The aim of groupware is to support people working together. Workflow and other groupware systems can provide to the company the necessary competitive advantages to maintain or to improve its position in the market by responding better and faster to customers. Nevertheless, the automation of business processes which have been structured without any consideration of CSCW technologies could not allow to organizations to reach long-dated objectives. Studies have shown that automating an existing manual work process will have a slight effect on productivity [MOR 91]. Instead, if the entire business process is reengineered to take into account capabilities provided by information and communication technologies, phenomenal increases in productivity can be achieved [HAM 90].

Companies are more and more made up by specialists who are hierarchically equal because of their competence in their own domain. Each « worker » can be evaluated according to his/her participation in business processes independently of any hierarchical consideration. Team organization enables a horizontal organization which reduces the hierarchical structure [SUN 94]. As opposed to a vertical organization, a horizontal one places the emphasis on communication and the capacity to react to market changes.

Until the middle of seventies, company organization was strongly production-oriented. They were producing a lot while using few qualified manpower thanks to the fragmentation of tasks. This is the principle of scientific management founded by Frederik W. Taylor. The resulting organization leads to a vertical division of work based on functional structures in an hierarchical structure which is sometimes very complicated. Today, the aim is not to produce but to produce efficiently in order to support selling. The increase in production capacity should not serve to increase the stock. The production process called "Just in Time

Business" requires organizations which can speed up decision making thanks to minimal hierarchical structures. This is the principle of horizontal company built on processes in contradiction to the vertical company built on functions. A process is a set of activities which produces (from one or several inputs) an output valuable for the customer [HAM 93]. This approach which consists of a complete remodeling of the organization around its processes is called "Business Process Reengineering" by Michael Hammer and James Champy [HAM 90], [HAM 93]. An horizontal organization emphasizes the communication and the capacity to immediately react to market changes. The essential preoccupation is to increase customer satisfaction. Business Process Reengineering (BPR) is completely dependent on the development of information technologies. BPR consists of analyzing and designing work processes in order to make them suitable to customers' needs. Information technologies are more than technical means to implement cooperative business processes. In fact, technological innovation offers an opportunity for organizational innovation. As advocated by [MED 92], if we adopt a computer support for cooperative work, we are directly concerned with its potential for business process reengineering.

Workflow management systems appear as providing an appropriate technical solution to reach quality objectives fixed by BPR. Too much companies are anxious about the quality of their services. In a more and more competitive market, quality is fundamental to obtain and to keep market share [GIT 87]. Workflow management systems can largely contribute to meeting the quality standards. In fact, these systems require strict observance of the predefined work processes, make easier the control of the process management and increase the safety level of processes.

QUALITY APPROACH

Stora and Montaigne [DUM 90] define quality as "... *the conformity of products or services with the needs expressed by internal or external customers and undertaken by internal or external suppliers*".

Quality assurance involves operational techniques and activities aimed both at monitoring a process and at eliminating causes of unsatisfactory performance at different stages of the quality loop. The ISO, ANSI, and Japanese standards are some ways of ensuring quality assurance.

The Quality Movement

The concept of quality went through four successive stages:

➔ *Inspection :* Around 1940, Taylor's theories about work organization came strongly into effect and caused a separation between producers and quality controllers. Quality was obtained essentially by the final control of the products.

➔ *Quality assurance:* Between 1950 and 1960, emphasis lay on the quality of the process and not only on the quality of the product. Roles and responsibilities between production and quality changed. The production function was responsible for the quality of its products, and controls were transferred to it. The quality function was responsible for the quality procedures necessary to meet customer needs.

➔ *Total quality management:* In 1980, experts acknowledged that the total management of quality is one of the factors in improved competitiveness.

The Total Quality Management (TQM) can be defined as a management method which aims towards long-range success. It is based on collective participation of each member in the improvement of processes, products, services and organization of the company. Each organization function is designed to contribute to the quality of the products and services. The key concepts of TQM are : quality, the customer/supplier relationship, zero defect, defect prevention and fact based quality.

➔ *Business Process Reengineering:* Companies must organize themselves to cope with change. They change to better satisfy customer requirements, address increasingly tough competition, improve internal processes, modify the range of products and services they offer [JAC 94]. This may require complete remodeling of the organization around its processes [HAM 90, HAM 93]. In such a case, Business Process Reengineering provides a solution.

The difference between TQM and BPR is that the former deals with continuous change whereas the latter deals with discontinuous, radical change.

ISO 9000 Standards

Most organizations produce a product or service intended to satisfy users needs or requirements. Such requirements are often incorporated in specifications. However, technical specifications may not in themselves guarantee that a customer's requirements will be consistently met. Consequently, this has led to the development of quality system standards and guidelines that complement relevant product or service requirements given in the technical specifications. The series of International Standards (ISO 9000 to ISO 9004) embodies a rationalization of the many and various national approaches in this sphere.

An organization should seek to accomplish the following three objectives with regard the quality:

- The organization should achieve and sustain the quality of the product or service produced so as to meet continually the purchaser's stated or implied needs.
- The organization should provide confidence to its own management that the intended quality is being achieved and sustained.

- The organization should provide confidence to the purchaser that the intended quality is being, or will be, achieved in the delivered product or service provided.

Activities aimed at providing confidence to the management of an organization that the intended quality is being achieved are often called "internal quality assurance". Activities aimed at providing confidence to the purchaser that the suppliers quality system will provide a product or service that will satisfy the purchaser's stated quality requirements are often called "external quality assurance".

The purposes of the ISO 9000 International Standard are [ISO 87, ISO 94] :

- to clarify the distinctions and interrelationships among the principal quality concepts,
- to provide guidelines for the selection and use of a series of International Standards on quality systems that can be used for internal quality management purposes (ISO 9004) and for external quality assurance purposes (ISO 9001, ISO 9002, ISO 9003).

The quality system elements should be documented and demonstrable in a manner consistent with the requirements of the selected model.

The ISO 9001 standard is a *« model for quality assurance in design, development, production, installation and servicing. This International Standard specifies quality system requirements for use where a contract between two parties requires the demonstration of a supplier's capability to design and supply product. The requirements specified in this International Standard are aimed at preventing nonconformity at all stages from design through to servicing* ».

The ISO 9002 standard is a *« model for quality assurance in production and installation, for use when conformance to specified requirements is to be assured by the supplier during the production and installation* ».

The ISO 9003 standard is a *« model for quality assurance in final inspection and test, for use when conformance to specified requirements is to be assured by the supplier solely at final inspection and test* ».

The ISO 9004 standard entitled «*Quality management and quality system elements - Guidelines* » provides guidance on the technical, administrative and human factors affecting the quality of products or services, at all stages of the quality loop from detection of need to customer satisfaction. Throughout ISO 9004, emphasis is placed on the satisfaction of the customer's need, the establishment of functional responsibilities and the importance of assessing the potential risks and benefits . All these aspects should be considered in establishing and maintaining an effective quality system.

ISO 9004 gives guidance to all organizations for quality management purposes. ISO 9001, ISO 9002 and ISO 9003 are used for external quality assurance purposes in contractual situations.

Principal concepts

Two key concepts are defined in the ISO 9000 standards:

- Quality control : «*the operational techniques and activities that are used to fulfill requirements for quality* » [ISO 87, §3.7]. Quality control involves operational techniques and activities aimed both at monitoring a process and at eliminating causes of unsatisfactory performance at relevant stages of the quality loop in order to result in economic effectiveness.
- Quality assurance : « *all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality* » [ISO 87, §3.6]. Unless given requirements fully reflect the needs of the user, quality assurance will not be complete. Within an organization, quality assurance serves as a management tool. In contractual situations, quality assurance also serves to provide confidence in the supplier.

Another concept complements these first ones: quality management. This is « *the aspect of the overall management function that determines and implements the quality policy* » [ISO 87, §3.5]. Quality control and quality assurance could be considered as mechanisms, to activate these mechanisms is the concern of quality management. The attainment of desired quality requires the commitment and participation of all members of the organization whereas the responsibility for quality management belongs to top management. Quality management includes strategic planning, allocation of resources and other systematic activities for quality, such as quality planning, operations and evaluations.

The quality system is constituted by «*the organizational structure, responsibilities, procedures and resources for implementing quality management* » [ISO 87, § 3.8]. For contractual, mandatory and assessment purposes, demonstration of the implementation of identified elements in the system may be required. The supplier shall establish and maintain a documented quality system as a means of ensuring that product conforms to specified requirements. This shall include 1) the preparation of documented quality system procedures and instructions in accordance with the requirements of this International Standard, 2) the effective implementation of the documented quality system procedures and instructions.

This series of International Standards on quality systems is intended to be used in two different situations: contractual and non-contractual. In both these situations, the supplier's organization wants to install and maintain a quality system that will strengthen its own competitiveness and achieve the needed product quality in a cost-effective way. In addition, in the contractual situation, the purchaser is interested in certain elements of the supplier's quality system which affects the supplier's ability to produce consistently the product or service to its requirements, and the associated risks. The purchaser therefore contractually requires that certain quality system elements be part of the supplier's quality system. The

quality system of an organization is influenced by the objectives of the organization, by the product or service and by the practices specific to the organization. Therefore, the quality system varies from one organization to another.

Use of the ISO 9000 International Standards on quality systems

For quality management purposes, after this International Standard has been consulted, reference should be made to ISO 9004 in order to develop and implement a quality system and to determine the extent to which each quality system element is applicable.

For contractual purposes, after this International Standard has been consulted, the purchaser and supplier should refer to ISO 9001, ISO 9002 and ISO 9003 to determine which of these International Standards is most relevant to the contract, and what specific adaptations, if any, have to be made. The selection of a model for quality assurance appropriate to a given situation amongst these three models should be done by systematic consideration of the following factors: design process complexity, design maturity, production process complexity, product or service characteristics, product or service safety, and economics.

The International Standard on quality systems requires the preparation of quality plans and a quality manual in accordance with the specified requirements. Quality manual is *« a document setting out the general provisions taken by an organization in order to obtain the quality of its products or services »* [ISO 87, §3.9]. Quality plan is *« a document setting out the specific quality practices, resources and sequence of activities relevant to a particular product, service or project. If there is a quality manual, quality plans are established with reference to it »* [ISO 87, §3.10]). These documents are the communication tools in the customer/supplier relationship. They allows also to memorize the knowledge and the know-how of the company.

As introduced in the first section, to conform to the ISO 9000 standards amounts "to write what is done, to do what was written and to prove what was done". The management of continuous improvement requires a set of steps called shewhart cycle which is shown in figure 4 [GIT 92]. These steps are given underneath:

1. *To prepare:* to write what will be done. This permits an examination of the coherence of decisions, and also ensures the continuity of actions. This step corresponds to the writing of quality assurance documents.
2. *To do:* to do what has been written. Things have to be strictly done in the way that it has been decided to do them.
3. *To inspect:* to write what has been done. This helps to prove that the planned actions have been accurately done.
4. *To take action:* to correct, to improve. The supplier has to take action by providing necessary modifications to the quality plan in order to better satisfy the customer.

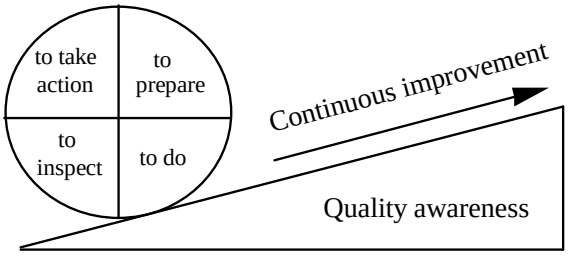

Figure 4 - *The four steps of quality assurance: shewhart cycle*

The ISO 9001 standard indicates that « *the supplier shall establish and maintain procedures to control all documents and data that relate to the requirements of this International Standard* ».

These requirements concern:

- Document approval and issue by authorized personnel:
  - Control of the document production, review, approval and issue
  - Availability of the issued documents for users,
- Document modifications:
  - Controlled access,
  - Identification of the revision,
  - Review and approval of changes to documents: establishing a master list for the current revision of documents, removing obsolete documents.

CONTRIBUTION OF WORKFLOW TO IMPLEMENT QUALITY

The use of a workflow management system may be crucial in every stage of the quality assurance management (see figure 5). The use of this kind of tool enables the company to ensure that procedures are always followed in the *to prepare, to do* and *to take action* stages and to evaluate their effectiveness *(to inspect).*

We have previously seen that workflow management systems provide mechanism to execute work processes with respect to predefined flow of tasks which may be executed by different actors having well known roles (see figure 5 - *to do*). It also allows us to improve the profitability of a company by removing bottlenecks and redundancy in treatments which are sometimes causes of errors. On the other hand, it is easy to make sure that only authorized people can take actions in the fixed time with reminders in the case of delay. Consequently, workflow management systems can also support procedures for quality assurance documents production (see figure 5 -*to prepare*- and figure 6).

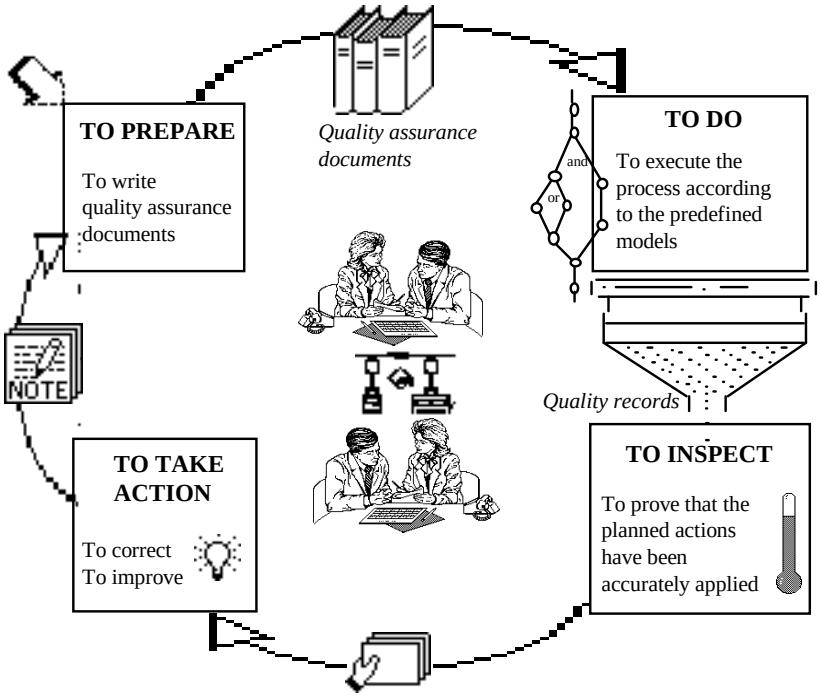

Figure 5 - *Quality assurance management*

A workflow application associated with a computer based document system makes information available at the right place and the right time. The management of document production by this kind of computerized systems allows in this way:

- to strengthen the sharing, the control and the treatment of information during the production,
- to increase the coherence of document production,
- to find information well adapted to each work group,
- to control the progress of current projects,
- to support the collaboration between actors and the coordination of actions,
- to improve the effectiveness of the process and the quality of the product or service.

As stated in the introduction, workflow management systems meet some requirements of the ISO 9000 International standards quite naturally. We assert that other requirements can be easily implemented using workflow. Finally, workflow has an impact on total quality management.

Workflow meets some requirements naturally

Workflow management systems meet some requirements of the ISO 9001 International Standard because in a workflow application predefined procedures are inevitably respected. The predefined actors can only execute tasks assigned to them.

Execution with respect to predefined procedures

Execution with respect to predefined procedures is all-pervasive in the ISO 9000 standard. Procedures can concern design control, documents and/or data, product identification and traceability, inspection and testing, quality records control or statistics.

A workflow procedure is a model which defines the way a work process will be executed. Since the procedure has to be enacted according to the model, the workflow administrator has to anticipate each possible case and exception for this procedure. Predefined procedures can then be modified only by authorized people.

Product identification and traceability

During the development of workflow applications, work processes must be totally defined and procedures, activities, roles and actors must be clearly identified. It is also essential to identify all documents and data required by the application. In the same way, each task is identified without ambiguity during execution. Different actors of an on going or completed procedure are well defined and work responsibilities of every one is clearly identified.

We note that a workflow management system is the right tool to implement identification procedures during the design and development of a product. It is easy to know how, when and by whom an element has been produced. That will allow us to prove to the purchaser that each planned stage and inspection has been respected.

Design input and design output control

Paragraph 4.4.3 of the ISO 9001 International standard indicates that *« Design input requirements relating to the product shall be identified, documented and their selection reviewed by the supplier for adequacy* ». Paragraph 4.4.4. adds that *« Design output shall be documented and expressed in terms of requirements , calculations and analyses. Design output shall meet the design input requirements; contain or reference acceptance criteria* ».

In workflow applications, inputs and outputs have to be imperatively identified and clearly defined. Outputs of task T are often inputs of task T+1 and the actor which has realized task T is responsible for them. Data flows between tasks and increases during the execution of the procedure. Data must be controlled in order to ensure that the specified requirements will be meet.

Measures

Paragraph 4.12 of the International Standard ISO 9001 says that *« the inspection and test status of product shall be identified by using appropriate means which indicate the conformance or nonconformance of product with regard to inspection and tests performed. The identification of inspection and test status shall be maintained, as necessary, throughout*

production and installation of the product to ensure that only product that has passed the required inspections and tests is dispatched, used or installed ».

Workflow management systems have appropriate mechanisms for the construction of dashboards. They provide information concerning time (time allocated to a procedure or an activity, time used to execute a procedure or task), activities, and procedures. Other indicators can be implemented according to the specifications of the application. During the design of workflow applications, different actors have to participate in requirements analysis in order to define metrics of performance. The corresponding indicators will then allow a critical analysis of procedures.

General and individual responsibilities

The International Standard ISO 9001 requires that *« The supplier's management shall define and document its policy and objectives for, and commitment to, quality. The supplier shall ensure that this policy is understood, implemented and maintained at all levels in the organization* » (§ 4.1.1). *« The responsibility , authority and interrelation of all personnel who manage, perform and verify work affecting quality shall be defined* » (§ 4.1.2.1).

A workflow application requires an authority who is responsible for each procedure. This is the person who will supervise each execution of this procedure, restart an execution in a dead-lock situation and resolves possible conflict situations.

Each activity in a procedure is assigned to a role, and during process enactment, each task is assigned to an actor. However, a workflow management system has no means to ensure that tasks are properly executed by actors. It is possible that an actor terminates his/hers task without doing any work. This bad task execution will be detected when its result will cause a coordination failure.

Meeting quality requirement through workflow applications

Some requirements of the ISO 9000 International Standards can be easily taken into account when developing workflow applications. Workflow may then facilitate the implementation of ISO 9000 International Standard requirements in organizations.

Design and development planning

The International Standard ISO 9001 requires that *« the supplier shall draw up plans that identify the responsibility for each design and development activity. The plans shall describe or reference these activities and shall be updated as the design evolves. The design and verification activities shall be planned and assigned to qualified personnel equipped with adequate resources*» (§ 4.4.2).

Workflow procedures permit the planning of a work process in its entirety. It is also possible to define a maximum duration for procedures as well as for each of their activities. When a procedure execution starts, its authorized duration is known. Moreover, a task can only be carried out by an actor having the required role and to whom the workflow management system provides required data when necessary.

Security

The concept of security is not explicitly mentioned in the ISO 9001 standard. However, it is stated several times that certain actions have to be taken by *« qualified and authorized personnel*». Paragraph 4.4.5 indicates that *« the supplier shall plan, establish, document and assign to competent personnel functions for verifying the design.*». Paragraph 4.5.1 specifies that *« documents shall be reviewed and approved for adequacy by authorized personnel prior to issue*».

In workflow applications, users can access controlled amount of information according to their role(s). Thus, actors receive only the right information at the right time.

Document and data control - Document versions

Paragraph 4.5.1 of the ISO 9001 standard specifies that *« the supplier shall establish and maintain written procedures to control all documents and data that relate to the requirements of this International Standard. These documents shall be reviewed and approved for adequacy by authorized personnel prior to issue. This control shall ensure that the pertinent issues of appropriate documents are available at all locations where operations essential to the effective functioning of the quality system are performed; obsolete documents are promptly removed from all points of issue or use* ».

Paragraph 4.5.2 of the ISO 9001 standard specifies that *« changes to documents shall be reviewed by the same functions/organizations that performed the original review and approval unless specifically designated otherwise. The designated organizations shall have access to pertinent background information upon which to base their review and approval. Where practicable, the nature of the change shall be identified in the document or the appropriate attachments. A master list or equivalent document control procedure shall be established to identify the current revision of documents in order to preclude the use of non-applicable documents* ».

So, the ISO 9001 International Standard imposes very strict rules for documentation purposes: review and approval of documents before issue, an exhaustive issue of new versions, suppression of obsolete documents etc. According to the ISO 9001 standard, documents and data may be stored on paper or an electronic medium.

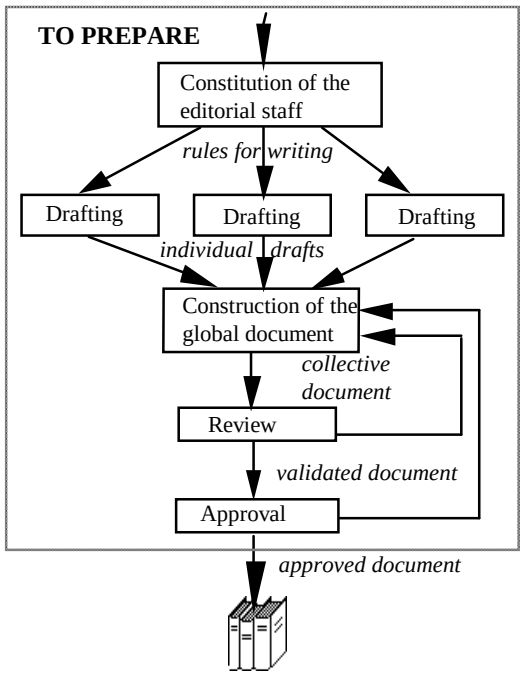

Figure 6 - *A procedure model for the production of a quality assurance document*

A workflow management system allows the implementation of procedures for approval, issue and modification of documents, particularly in the presence of an automated document system. Then, version management of documents is performed by this system. Different versions of documents can be filed or stored. In general, the last version of a document is accessible directly, and the others only on specific request of authorized people.

The production cycle of a document can be described using a workflow procedure (see figure 5 - *to prepare* - and figure 6). Each type of document identified by its characteristics and its production cycle can be associated to a specific procedure. In a workflow application, it is also possible to create different views on documents with respect to the rights and roles of each actor.

Quality records

Paragraph 4.16 of the ISO 9001 standard specifies that « *quality records shall be maintained to demonstrate achievement of the required quality and the effective operation of the quality system. All quality records shall be legible and identifiable to the product involved. Quality records shall be stored and maintained in such a way that they are readily retrievable in facilities that provide a suitable environment to minimize deterioration or damage and to prevent loss. Retention times of quality records shall be established and recorded. Where agreed contractually, quality records shall be made available for evaluation by the purchaser or his representative for an agreed period* ».

There are two types of quality records:

- *Records related to quality achievement* : they demonstrate that the required quality is achieved. These are, for example, inspection records.
- *Records related to quality assurance* : they are intended to demonstrate the effective operation of the quality system, for example, internal quality audits.

These records can be realized during each task of a workflow procedure and stored.

Records related to quality are directly prepared by the workflow management system (see figure 5) which will retain them until the actor responsible for the procedure stores or removes them. Records can be retained for an agreed period and used, for example, to demonstrate to the purchaser that operations have been carried out at the right time by the authorized personnel.

The supplier shall also carry out a system of planned and documented internal quality audits to verify whether quality activities comply with planned arrangements and to determine the effectiveness of the quality system.

Workflow and TQM

Total quality is based on five essential principles:

1. Responsibility: every one must feel concerned by the quality system.
2. Measurement: quality data must be collected to ensure that the product or service meets the purchaser's quality requirements.
3. Conformity: satisfying completely the purchaser's needs.
4. Excellence: executing tasks without error and reaching the "zero defect" objective.
5. Prevention: eliminating causes of errors as soon as possible in work processes.

Workflow can be used as a tool for facilitating the implementation of total quality. It helps in administering the quality approach better, (§ 4.3.1), facilitates actor acceptance of the quality approach (§ 4.3.2), contributes to quality by offering better workload and improved efficiency (§ 4.3.3), and, finally, due to its simulation capabilities, workflow can be used to verify the consistency of procedures before their real execution (§ 4.3.4).

Administrative processes

The implementation of a quality approach often requires an adaptation and sometimes a reengineering of business processes. It implies increased workload on members of the organization who resent it since they do not perceive any immediate benefits. Workflow may be used as a tool allowing to decrease the workload implied by the quality system. For example, the automation of the document flow frees actors from worrying about information

transmission. Through use of workflow, changes in staffing patterns and work allocations to individuals, quality is not compromised because quality procedures are encoded in the workflow application and not in the individual actors. It is only necessary for the system administrator to inform the workflow of all changes in actors and their responsibilities.

Workflow application can also be used to produce quality documents required by the ISO 9000 International Standards. These documents, for example inspection reports for each task, will then be automatically produced by the workflow management system during the execution of the corresponding tasks.

Facilitating personnel acceptance

A management decision to introduce TQM or ISO 9000 leads to an increase of workload of actors in the organization. This results in actor resistance. However, when automated workflow support is provided, actors tend to accept the change better. Therefore, the adoption of workflow leads to actor acceptance of quality in the organization.

Workload adjustment

While designing a workflow application it is possible to specify that the least loaded actor in a role shall carry out an activity assigned to the role. The workflow management system can automate this task allocation. If the person responsible for the procedure finds that every actor in the role is overloaded then the corresponding role can be assigned to another (new) actor who will then execute this task.

A workflow management system allows in this way a better adjustment of the workload and more efficiency in work thereby contributing to better quality.

Prototyping

During business process reengineering (see section *the quality movement*), often proceeding the implementation of workflow applications, simulations are essential. Work processes, reengineered or not, have to be tested before implementation. A workflow management system allows the construction of prototypes by parameterizing the information flow, the frequency and time estimated for each task thereby permitting verification of the consistency of the procedures which will be implemented. By detecting errors in the designed procedures workflow guarantees their implementation without error.

In this way, prototyping through workflow plays a major role in satisfying three goals of total quality: conformity, excellence and prevention.

CONCLUSION

Ensuring quality of products and services requires high amounts of cooperation between

the different actors in an organization. This made us investigate the use of CSCW techniques to implement quality. Workflow is a CSCW technique based on modeling of pre-defined procedures. Therefore, it can, in a very natural way, support the implementation of quality procedures . Additionally, it is possible to build an application around workflow. When this is done then a number of quality requirements can be represented in the application. Workflow management systems can automate these requirements. Finally, workflow becomes integrated with total quality management. It facilitates the satisfaction of the five essential principles of TQM.

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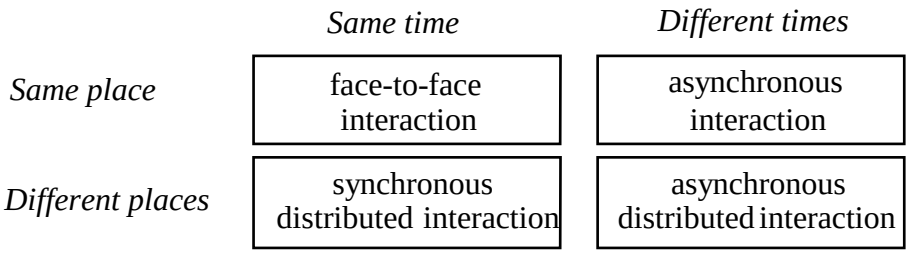

Figure 1 - *Johansen's Space/Time matrix*

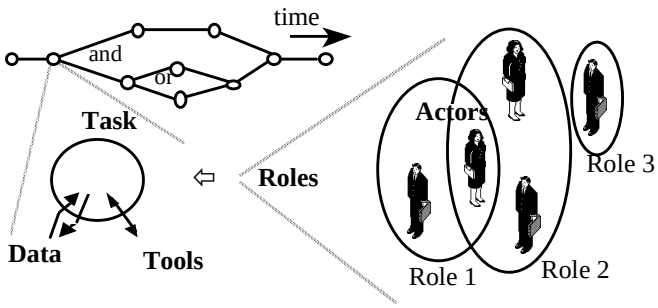

Figure 2 - *Procedure representation*

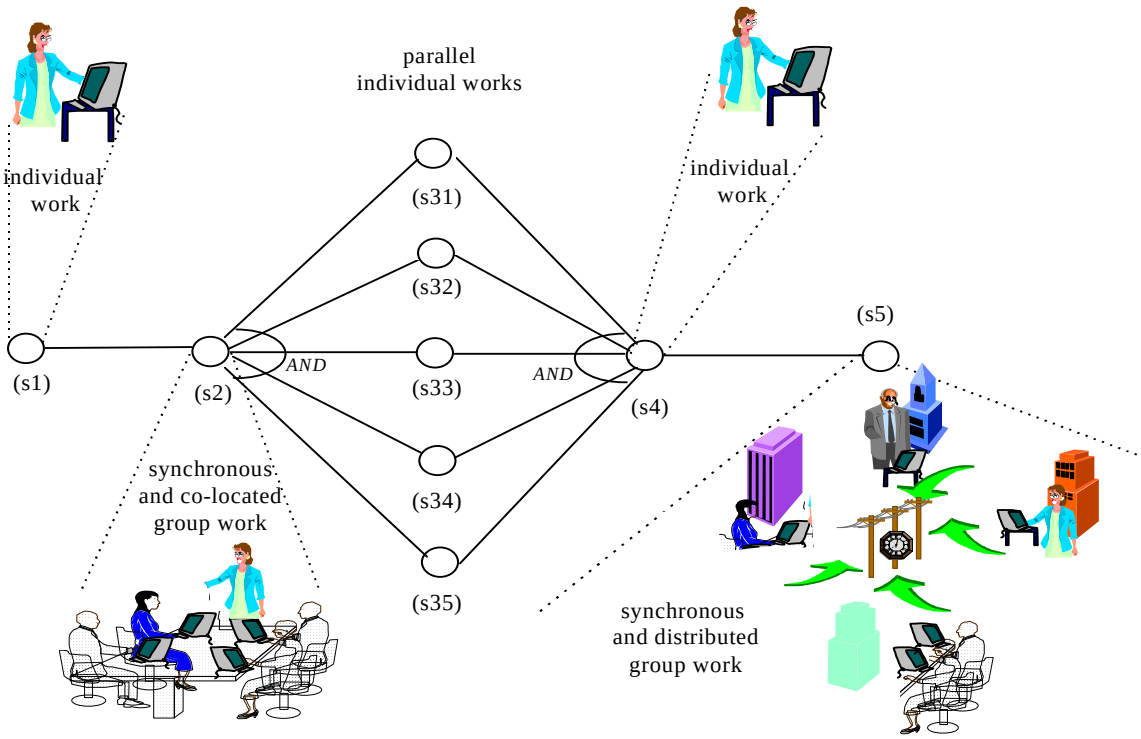

Figure 3 - A well-defined asynchronous cooperative process coordinating individual and cooperative works

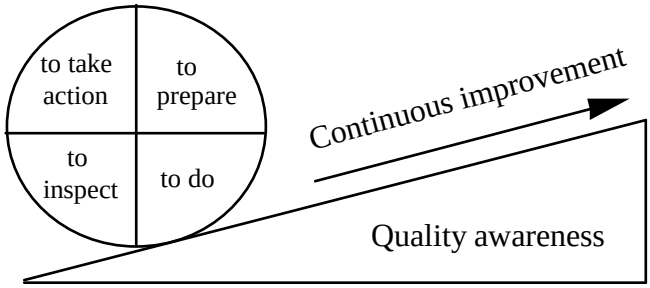

Figure 4 - *The four steps of quality assurance: shewhart cycle*

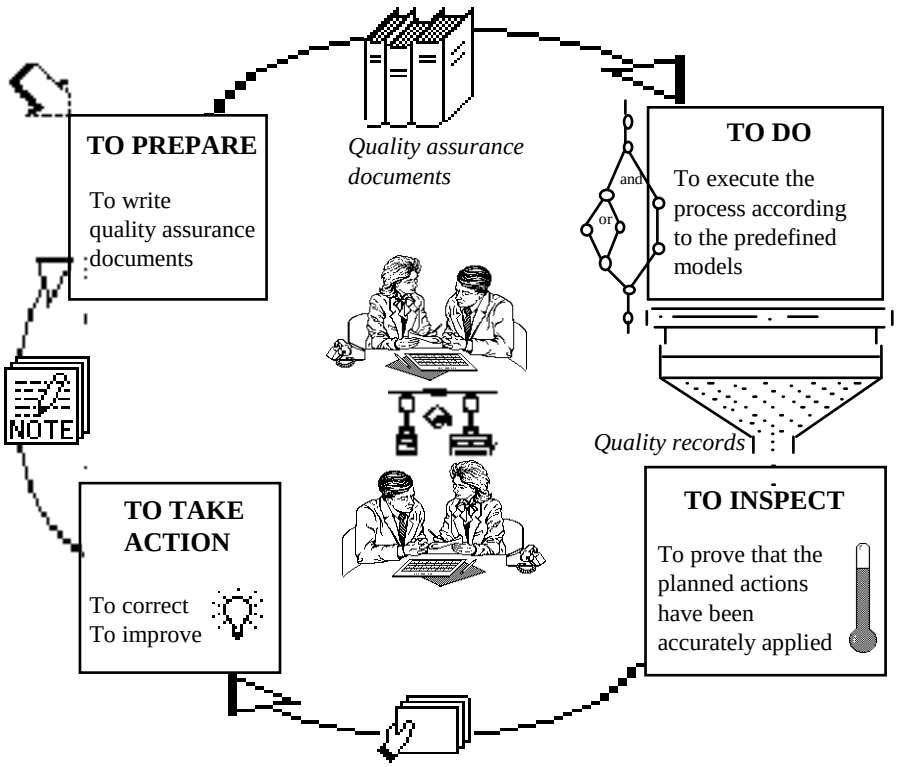

Figure 5 - *Quality assurance management*

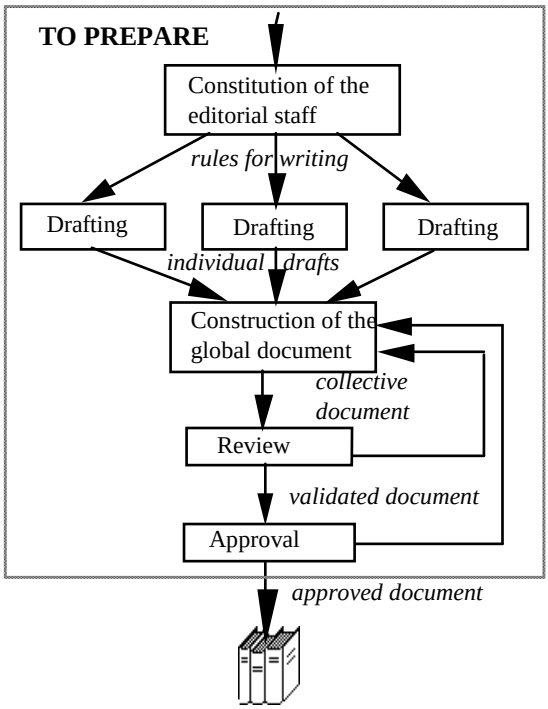

Figure 6 - *A procedure model for the production of a quality assurance document*